Summer 2013

A petrologic study of the Teanaway Basalt: Eocene slab window volcanism in Central WA

Liz Roepke
University of Puget Sound, liroepke@pugetsound.edu

A petrologic study of the Teanaway Basalt: Eocene slab window volcanism in Central WA

Elizabeth Roepke*, Jeff Tepper, Andrew Ivener
University of Puget Sound
e.w.roepke@gmail.com

ABSTRACT

The Teanaway Basalt (TB) includes subaerial basalt to andesite flows, mafic to felsic tuffs, and rhyolite domes in the Central Cascades of Washington State. These volcanics overlie the extensive ~47 Ma Teanaway Dike Swarm (TDS) that cuts the underlying Swauk Formation. Samples were collected from 3 main localities: Easton Ridge (ER) in the west, Liberty Ridge (LR) in the east, and the Middle Fork of the Teanaway River (MF) in the center (See fig. 1).

The bimodal TB consists predominantly of basaltic andesite and andesite (45.3–63.1 wt% SiO_2) with subordinate rhyolite (75.9–79.4 wt% SiO_2). The mafic rocks classify as primarily medium-K tholeiites (0.1–3.0 wt% K_2O), but a few samples classify as alkaline. Possible tectonic settings suggested by graphs and diagrams include an arc setting, MOR, or within-plate volcanism.

ER and LR differ mainly in REE contents, and also show different concentrations of Fe_2O_3T, TiO_2, MnO, and Na_2O. Pearce element ratio plots suggest much of the variation reflects different degrees of plag+cpx fractionation. With increasing stratigraphic height LR samples exhibit a general trend of decrease in SiO_2 and increase CaO, MnO, P_2O_5, and cycles of decrease followed by increase in Mg#.

RESEARCH QUESTIONS

The focus of this study was to synthesize geochemical data (major and trace elements, REE, and Pb isotopes) in order to determine a plausible tectonic setting and analyze chemical differences according to location and stratigraphy. The main research questions were as follows:

- What was the tectonic setting of eruption for the TB?
- How is the TB chemically varied across the formation? Stratigraphically?

FIELD AREA

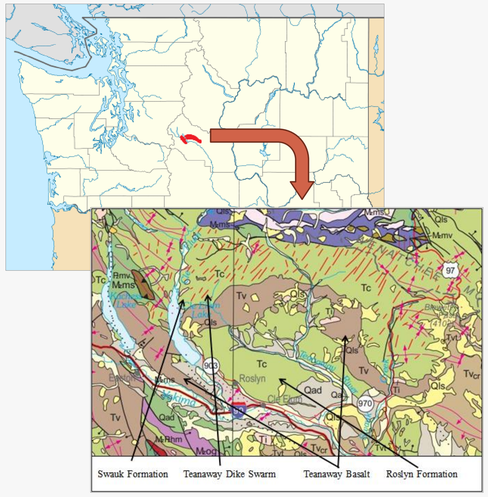
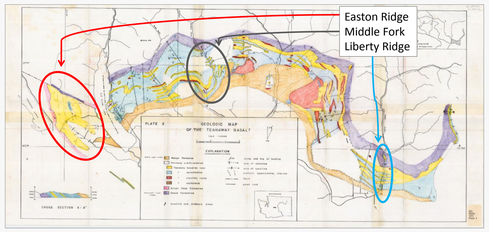


Figure 1. Geologic context of the TB, with TB, TDS, and immediately surrounding formations labeled (above). Geologic map (Clayton, 1973) of the TB showing sample locations (below).



TECTONIC SETTING

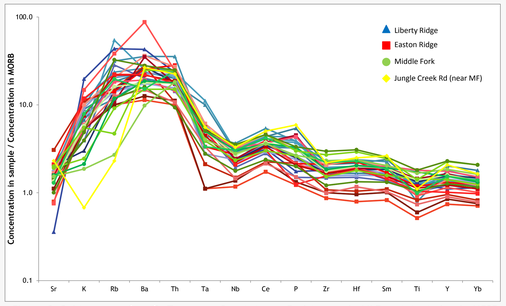


Figure 2. Spidergram of mafic Teanaway Basalt lavas. Enrichment in LILE and depletion in HFSE indicate an arc setting. Samples low in K and Rb likely have been highly altered, depleting those elements.

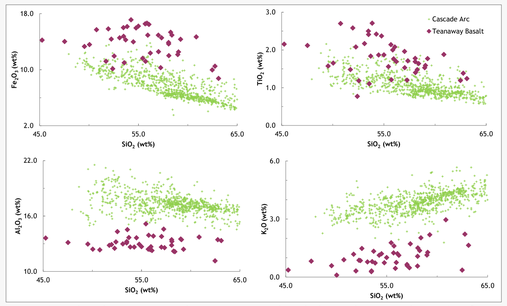


Figure 3. Harker plots comparing the Teanaway Basalt with the modern Cascade Arc. Significant differences in chemical composition signal separate sources and processes of formation.

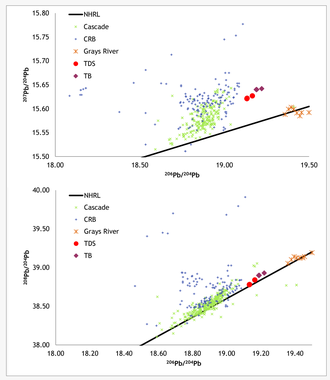


Figure 4. Preliminary radiogenic lead isotope ratio plots displaying the TB in context of local (WA) volcanic centers and the Northern Hemisphere Reference Line (NHRL) for primitive mantle magmas. The TB and TDS plot outside the CRB and Cascade data ranges, indication different sources and/or formation processes. The deviance from the NHRL on the 207Pb/204Pb vs. 206Pb/204Pb plot is possibly due to contamination from continental crust material. Note: TB and TDS each display 2-step leeches of a single sample, not multiple samples.

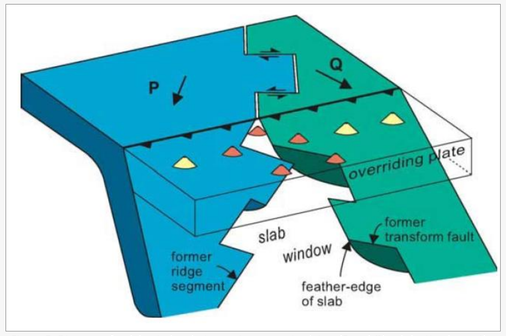


Figure 5. Diagram of a slab window between two oceanic plates (P and Q) subducting beneath a continental plate. In this model, the spreading-ridge is at a large angle to the continental margin. (Thorkelson & Breitsprecher, 2005).

GEOGRAPHIC VARIATION

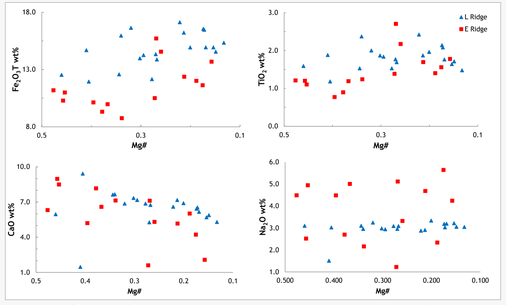


Figure 6. Harker plots of various major elements vs. Mg# comparing LR to ER. ER is generally lower and more varied in concentration, suggesting a more primitive source magma and multiple parent magmas.

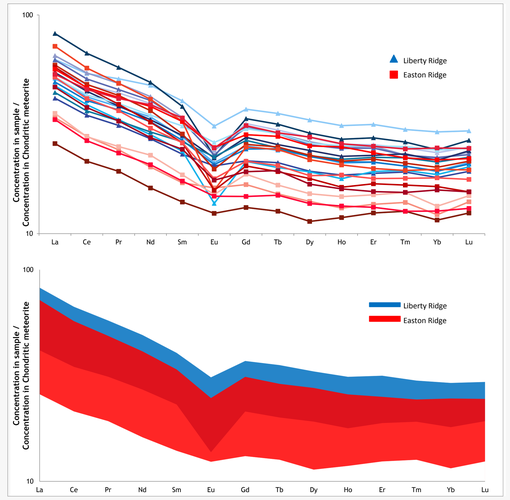


Figure 7. REE plots comparing LR to ER. LR and ER have similar slopes but slightly different Eu anomalies, suggesting fractionation was a factor in differentiation. ER is generally lower in REE contents, suggesting a more primitive source, consistent with the Harker diagrams in fig. 6.

STRATIGRAPHIC VARIATION

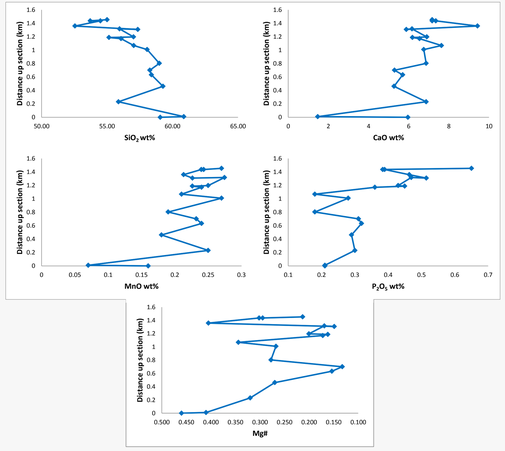


Figure 8. Distribution of major elements and Mg# through LR section. Samples collected along LR trail and Highway 97 (see fig. 1). Decrease in SiO2 and increase in MnO upsection suggest magmas became more primitive over time.. Cycling of Mg# suggests repeated periods of maturation followed by replenishment events.

CLASSIFICATION DIAGRAMS

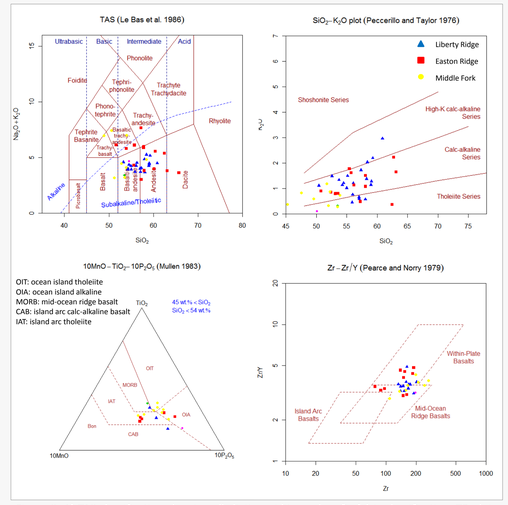


Figure 9. A) TAS classification showing alkalinity, acidity, and mafic-felsic classification. TB plots in both alkaline and sub-alkaline areas, which is unusual. B) K classification plot showing varying K level for Tb samples. C & D) Tectonic discrimination plots showing the various settings suggested by TiO_2, MnO, and P_2O_5 ratios (C) and Zr/Y –Zr ratios (D).

CONCLUSIONS

Enrichment in LILE and depletion in HFSE on spidergrams are indicative of an arc setting. However, compared with the modern Cascade Arc, the TB is distinctly higher in Fe_2O_3T and TiO_2 and distinctly lower in Al_2O_3 and K_2O, within a similar range of Mg #s. Preliminary Pb isotopic data indicate the TB and TDS are more enriched than Cascade Arc rocks in $^{206}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$.

Both LR and ER samples display modest LREE enrichment (La/Yb = 2.1-3.7) and similar incompatible element ratios, suggesting similar sources. Stratigraphic trends in the LR section are suggestive of an evolving system that experienced multiple replenishment events.

Overall, these geochemical data are consistent with a model in which asthenospheric mantle ascending through a slab window interacts with mantle wedge that has previously acquired arc chemical traits. Stratigraphic trends in the LR section are suggestive of an evolving system that experienced multiple replenishment events. The existence of a slab window in this region during the mid-Eocene is compatible with plate reconstructions and evidence of extension that have been attributed to subduction of the Resurrection-Kula ridge (Haeussler et al., 2003).

REFERENCES

Clayton, D. N. (1973). *Clayton 1973 - Volcanic History of the Teanaway Basalt.pdf* (Master's). University of Washington.

Haeussler, P. J., Bradley, D. C., Wells, R. E., & Miller, M. L. (2003). Life and Death of the Resurrection Plate: Evidence for its existence and subduction in the Northeastern Pacific in Paleocene-Eocene time. Geological Society of America Bulletin, 115(7), 867–880.

Thorkelson, D. J., & Breitsprecher, K. (2005). Partial melting of slab window margins: Genesis of adakitic and non-adakitic magmas. Lithos, 79, 25–41.

ACKNOWLEDGEMENTS

I would like to thank the University of Puget Sound Geology Department, University of Washington Geology Department, and the National Science Foundation for providing resources and funds contributed to this project, and Prof. Jeff Tepper and Drew Ivener for research guidance, research and analysis help, and Anne Fetrow for her input into this poster.